How Does the Presence of Extrasolar Planets Affect the X-ray Output of Hot Stars?

The Power of AND | University of Wisconsin Eau Claire

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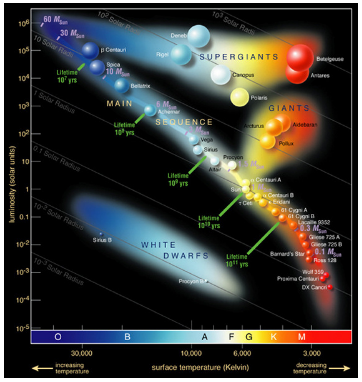
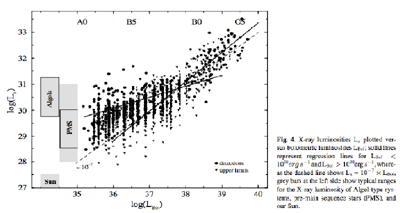


Hertzsprung-Russell Diagram – shows stellar evolution along the main sequence. Stars are graphed according to their luminosity and temperature[1].

Introduction

O and B-type stars are among the hottest, most luminous, and most massive stars in space, with O-stars comprising a mere 0.00003% of main sequence stars. Due to their extreme temperatures, appreciable amounts of ionizing radiation are emitted in the form of X-rays. O-stars generally follow the 10^{-7} Law, where one ten-millionth of the star's luminosity comes out as X-rays. Using results from Berghofer et. al., our goal was to determine if the presence of exoplanets around O-stars can explain the scatter about the canonical 10^{-7} Law.



Berghofer et. al. illustrates the 10-7 law for O-type and early B-type stars[2].

Materials and Methods

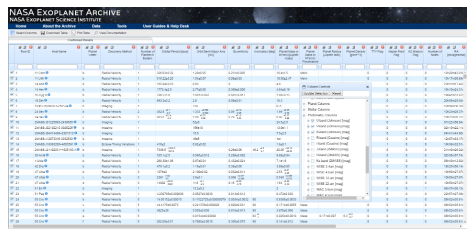
The primary source of stellar and planetary information was the NASA Exoplanet archive. The archive contains all candidates and confirmed exoplanets to date, as well as attributes from their host stars. The data has been compiled using various surveys from ground and space telescopes, including:

- Kepler Spacecraft
- CoRoT Space Observatory
- Chandra X-Ray Observatory
- SuperWASP Planet Detection Program

Abstract

Our perception of the universe has changed drastically within the past decade due to new advancements in astronomical telescopes and exoplanet search methods. The recent surge in exoplanet discoveries has given rise to many new questions regarding the properties of our universe and stellar activity. In this project, we investigated exoplanets orbiting OB-type stars because most research so far has focused on the exoplanets orbiting sun-type stars. Using the NASA Exoplanet Archive containing all confirmed exoplanet discoveries to date, our goal was to investigate the possible effect of exoplanets on the X-ray output of OB-type stars.

NASA Exoplanet Archive

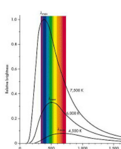


The NASA Exoplanet archive used to analyze stellar and planetary properties. Data was exported to Excel 2011 for analysis.

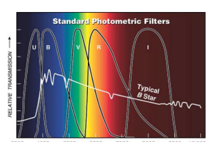
Determining Stellar Spectral Types

In order to investigate the effects of exoplanets on O-type stars, the exoplanet archive was sorted by the spectral type of host stars. However, since not all spectral types were explicitly listed, stellar spectral types were determined by their photometric properties.

UBV Photometric System and the Color Index



Radiation curves for stars – decrease in λ_{max} results in an increase in temperature and brightness[3].



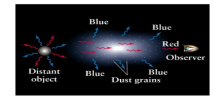
The radiation curve for a typical B-star with UBVRI filters applied[4].

In stellar astronomy, filters are applied when analyzing the light from stars. The UBV photometric system uses three narrow-band filters, where U filters ultraviolet wavelengths, B filters blue wavelengths, and V filters wavelengths in the visible spectrum. From these measurements, we can determine the true "color" of a star using the color index. This measures the magnitude difference between blue and visible light (B-V). By taking the difference in these values, magnitude changes that occur based on the distance from the star to observer are eliminated.

Interstellar Reddening

Dust particles in the interstellar medium affect the light we observe from stars. Stars appear more red than they really are. For any given star the ratio of color excess in B-V and U-B is constant, that is:

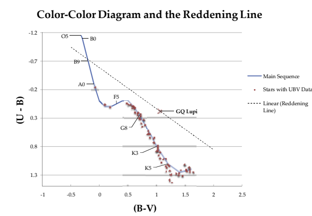
$$\frac{E(U-B)}{E(B-V)} \approx 0.72$$



Blue wavelengths are scattered by dust, while red wavelengths pass through to the observer, making the star appear more red[5].

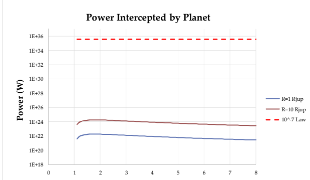
Results

The color-color diagram graphs stars according to the color index (B-V), as well as U-B magnitudes. From this, interstellar reddening can be applied to determine the true spectral type of stars earlier than A0. Only one star with UBV data appeared to be a reddened late O-type or early B-type star.



Spectral types for main sequence stars are graphed according to their colors. The star along the reddening line shown turned out to be GQ Lupi, a well-known star with spectral type K7.

Modeling a Typical O-Star



Planets sizes are in terms of Jupiter radii, as some exoplanets can range from 1-10 R_{jup} while orbiting close to their host stars. The total luminosity of Tau Scorpii was used to generate the 10^{-7} Law line.

Without empirical evidence of planetary effects on O-stars, we modeled the interaction between the stellar winds of a typical O-star, Tau Scorpii, and an exoplanet at various distances from the star. Along with the stellar wind parameters of Tau Scorpii, we used the planet radius and orbital radius to determine the power intercepted by a planet from the stellar winds.

Conclusion

Although the NASA Exoplanet Archive did not provide an O-star as a confirmed host star, we may be able to explore this type of star as more exoplanet candidates become confirmed. Our intercepted power model demonstrates that stellar wind-planet interactions are not significant enough to describe the large scatter around the 10^{-7} line, particularly the points that lie above. Going forward, similar stellar wind models could be used to investigate wind-planet interactions and their effects on one another. Though they are rare, we expect that more O-stars will be found due to their extreme brightness in the night sky.

References

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